Temperature rumen bolus able to record intake and drinking behavior for dairy small ruminants

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Motivation

- Currently available rumen bolus equipped with sensors were developed for cattle monitoring →but not for small ruminants

↓

due to the large size capsules

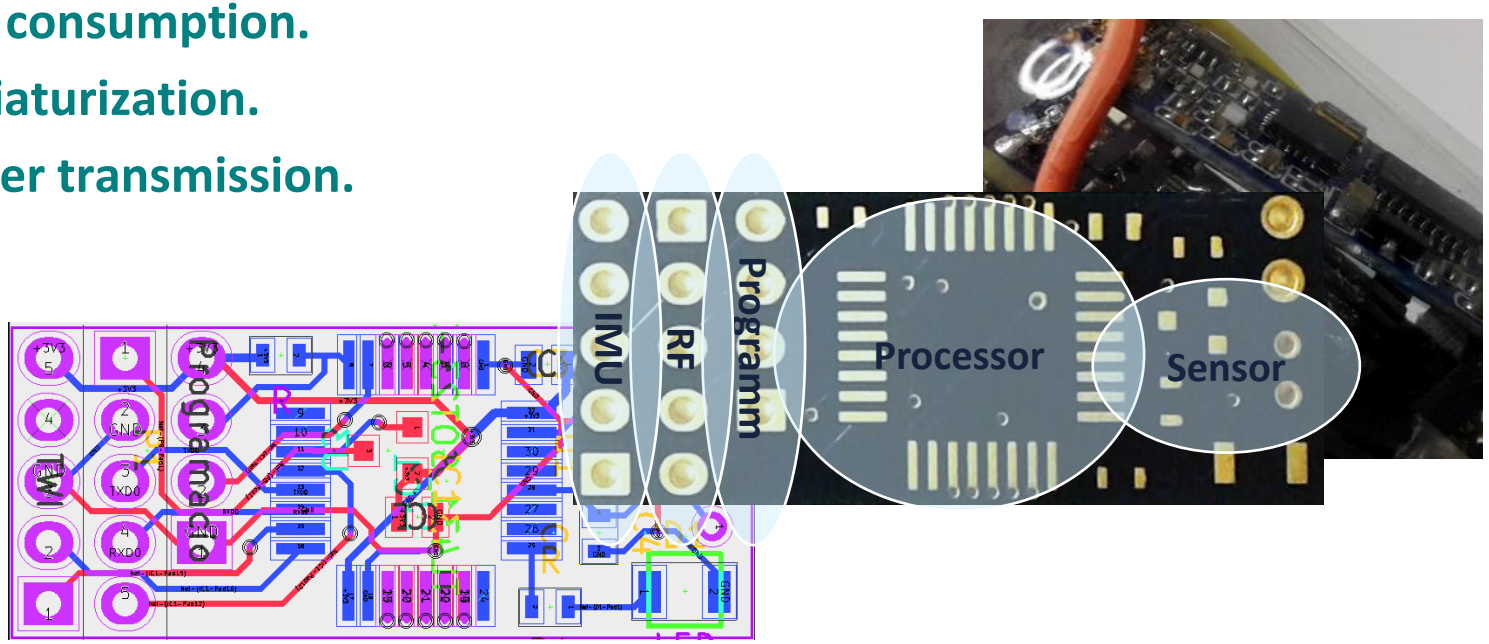
With the aim of solving this limitation → we developed a small rumen bolus designed to monitor the rumen temperatures and movements of sheep and goats

BIOSENS bolus objective:

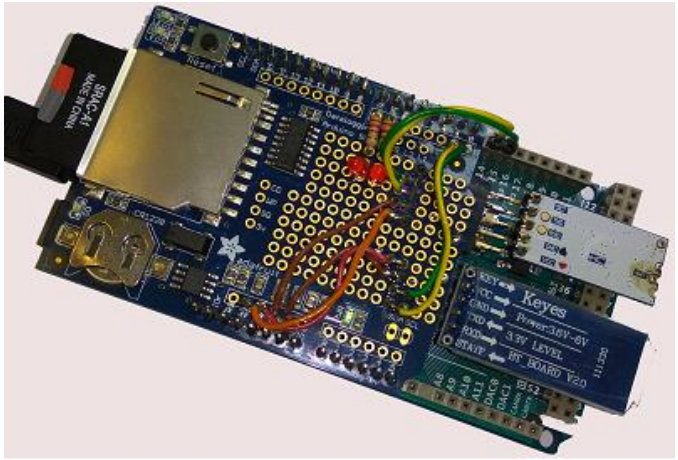
→ external diameter, 20-22 mm; length, 80-100 mm, weight, 50-70 g

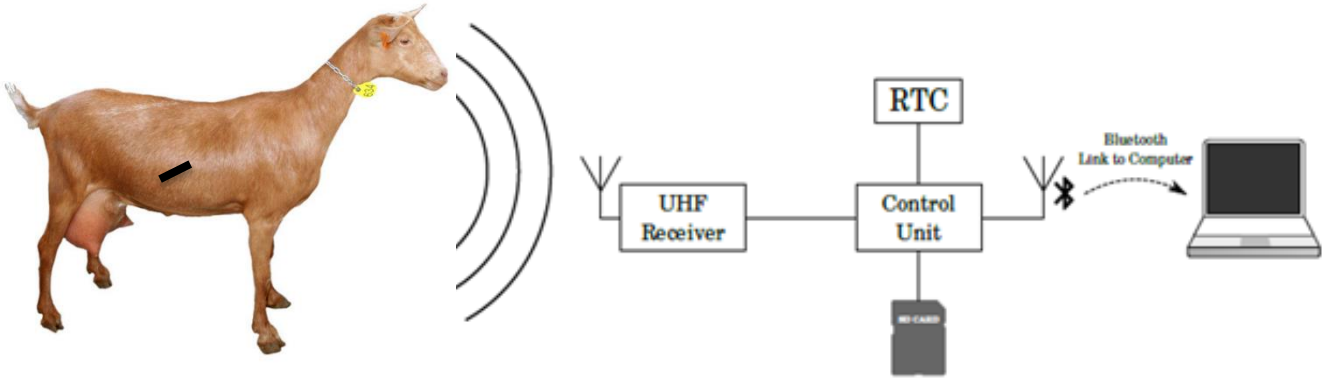
HW Platform Architecture

- **Bolus internal circuitry requirements:**
  - Though at the moment it senses temperature and movement, the general setup allows the sensing of other physical quantities.
  - Low consumption.
  - Miniaturization.
  - Power transmission.

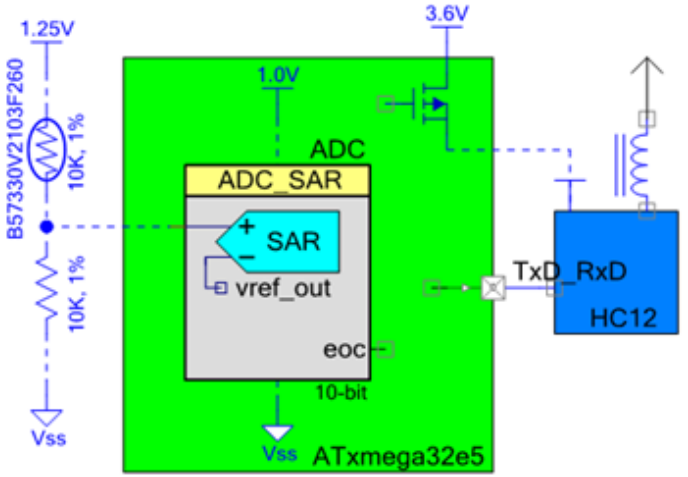


Bolus System approach





Bolus architecture



- Thermistor connected to the μC for temperature sensing.
- In the microcontroller, an ADC (12 bits) is responsible for the analogue to digital conversion.
- Obtained raw data is sent via serial port and transmitted at 434 MHz.
- Battery powered.
- Other sensors can be included. Care with battery power consumption must be considered.

The Bolus: Dimensions & Precision

- **Dimensions:**
  - Weight: 60 g.
  - Size: 100 mm * 20 mm.
  - Density is > 2.43 g/cm^3.
  - Printed Circuit Board size: 14 mm * 30 mm.
  - Battery diameter: 19 mm.
- **Precision:**
  - ADC is 12 bits, produces a resolution in the circuit of 42 steps/°C → 0.023°C.
- **Errors in the measurement:**
  - Load resistor tolerance = 1%
  - Thermistor tolerance = 1%
  - Vref (thermistor) tolerance = 2%
- **What traduces in a tolerance in the circuit of 1.1°C**
  - → **Calibration is required!**

The Bolus: Power Consumption

- **Power consumption:**
  - **Battery size: AA/2**
  - **Consumptions:**
    - In sleep: 8 μA
    - Processing: 1.7 mA
    - In transmission:
      - At 20 dB: 120 mA
      - At 17 dB: 69 mA
      - At 14 dB: 57 mA

    (Note: each 6 dB reduction, implies half the distance transmission)

Battery considerations

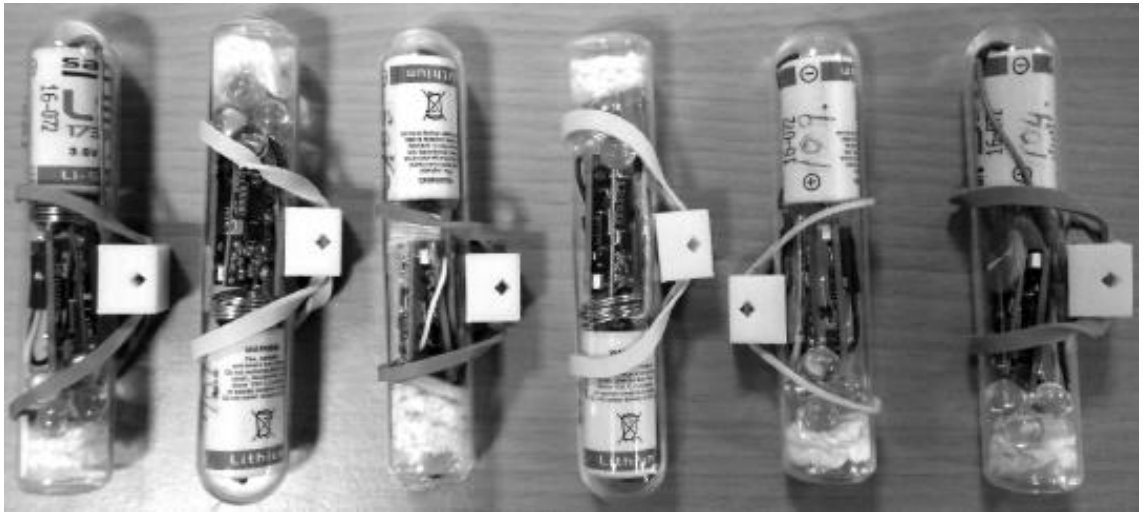
Battery datasheet specificy:

- A maximum constant current drain
- A maximum pulse width and current drain for period.

Used bolus battery specifications are:

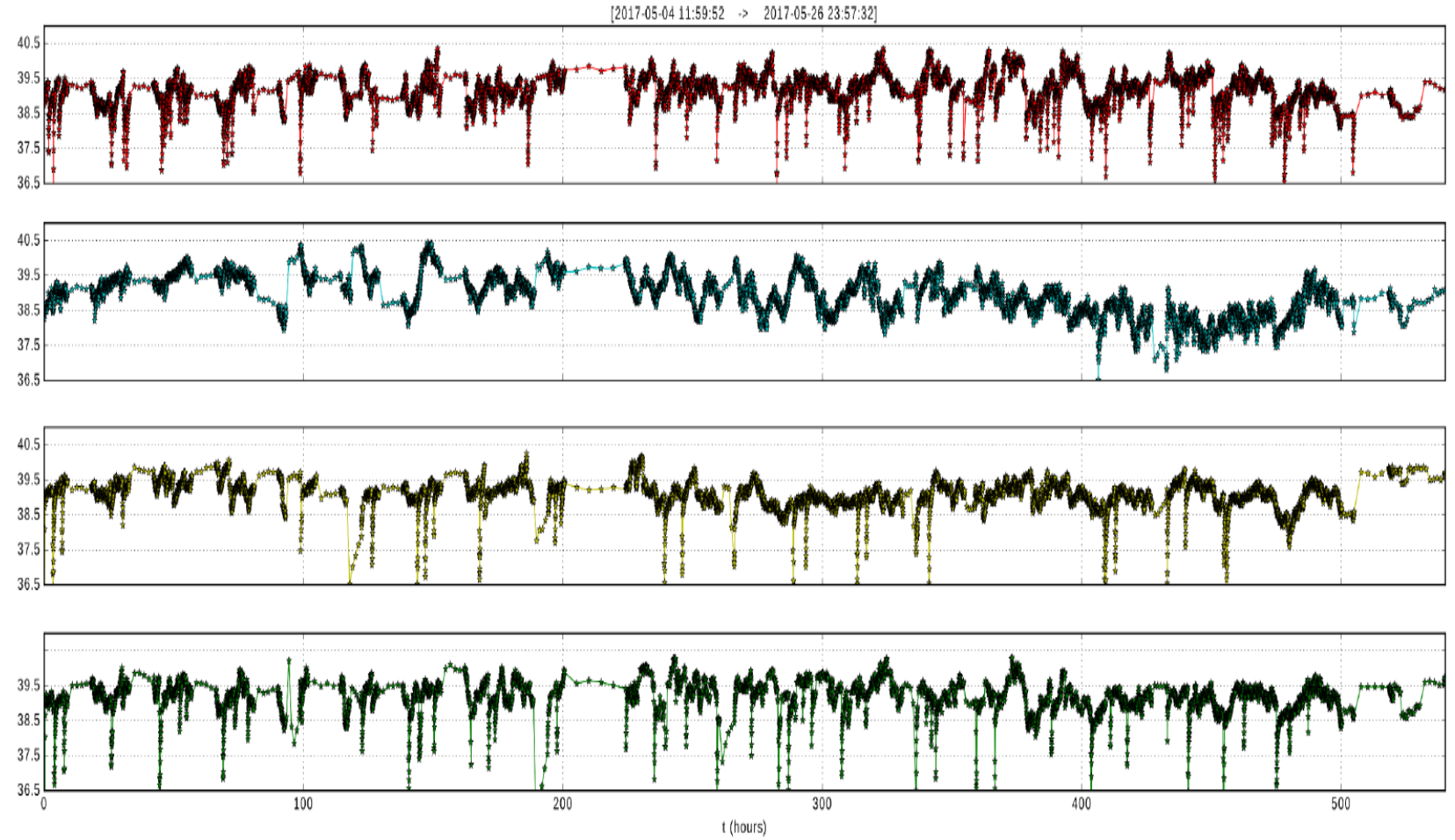
- 2100 mA/hour
- Maximum constant current drain = 25 mA
- Peak: 100 mA for a 100 ms pulse each 2 min.

First small Bolus experimentation (BT1)



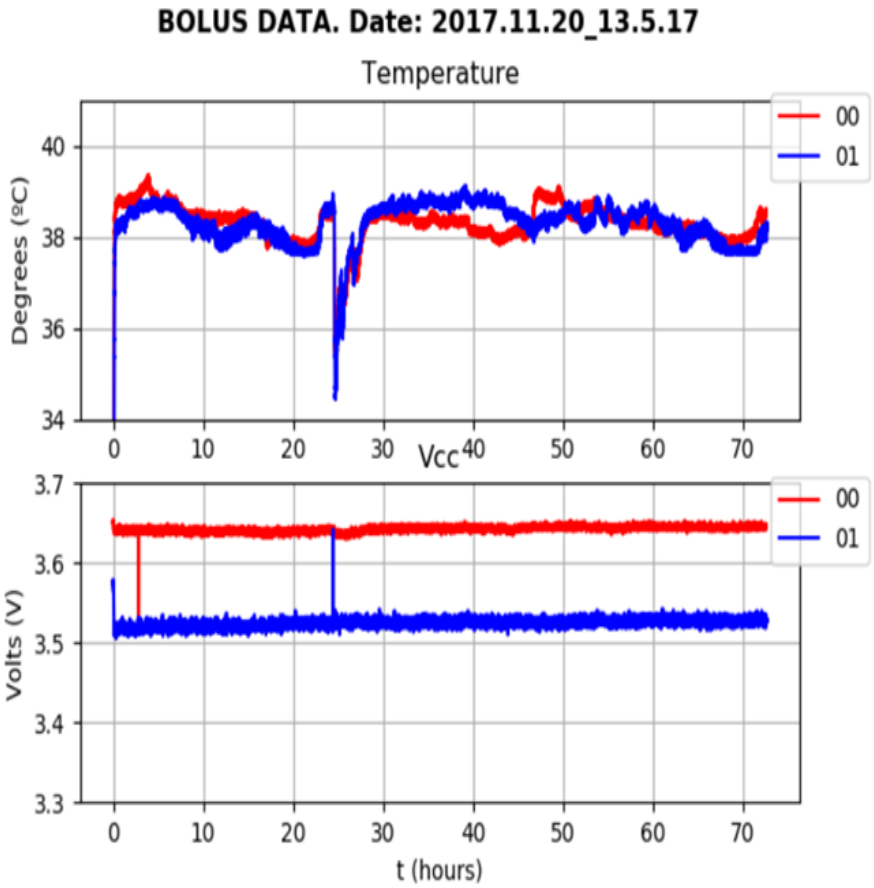
- In June 2016, 6 bolus were packaged in glass were implanted in ewes.
- These bolus, in a 168 days trial, showed degradation. It was not seen in any other bolus previously used.
- After the later analysis, the problem seemed to be due to the degradation of the battery. It is supposed to be due to:
  - Too demanding battery power pulses.
  - Degradation due to excessive heating during glass sealing.

Experimental results (4 BT1 applied in dry ewes)



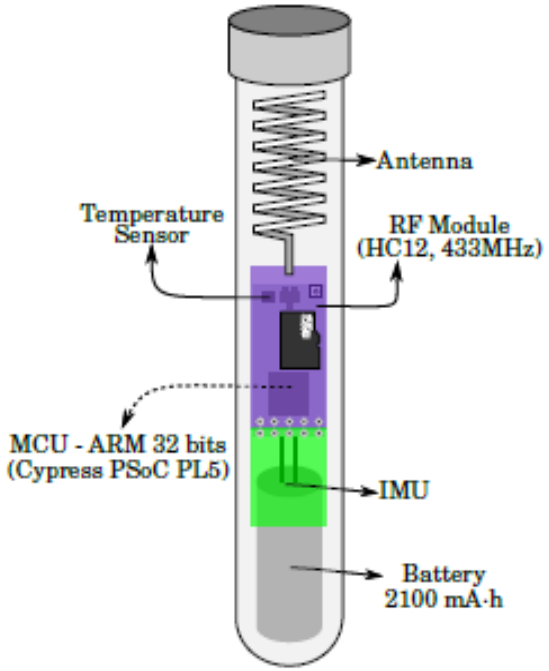
Second bolus experimentation (BT2)

- **Two bolus introduced in dairy ewes:**
  - Weight: approximately 60 g.
  - Dimensions: 100 mm * 21 mm.
  - Material: Plastic, with epoxy sealing in the caps.
  - Programming setup: 103 ms duration of data emission pulse.
  - Frequency: emission every 2 sec.
  - Transmission power: bolus 0 set at 17dB, bolus 1 at 14 dB.

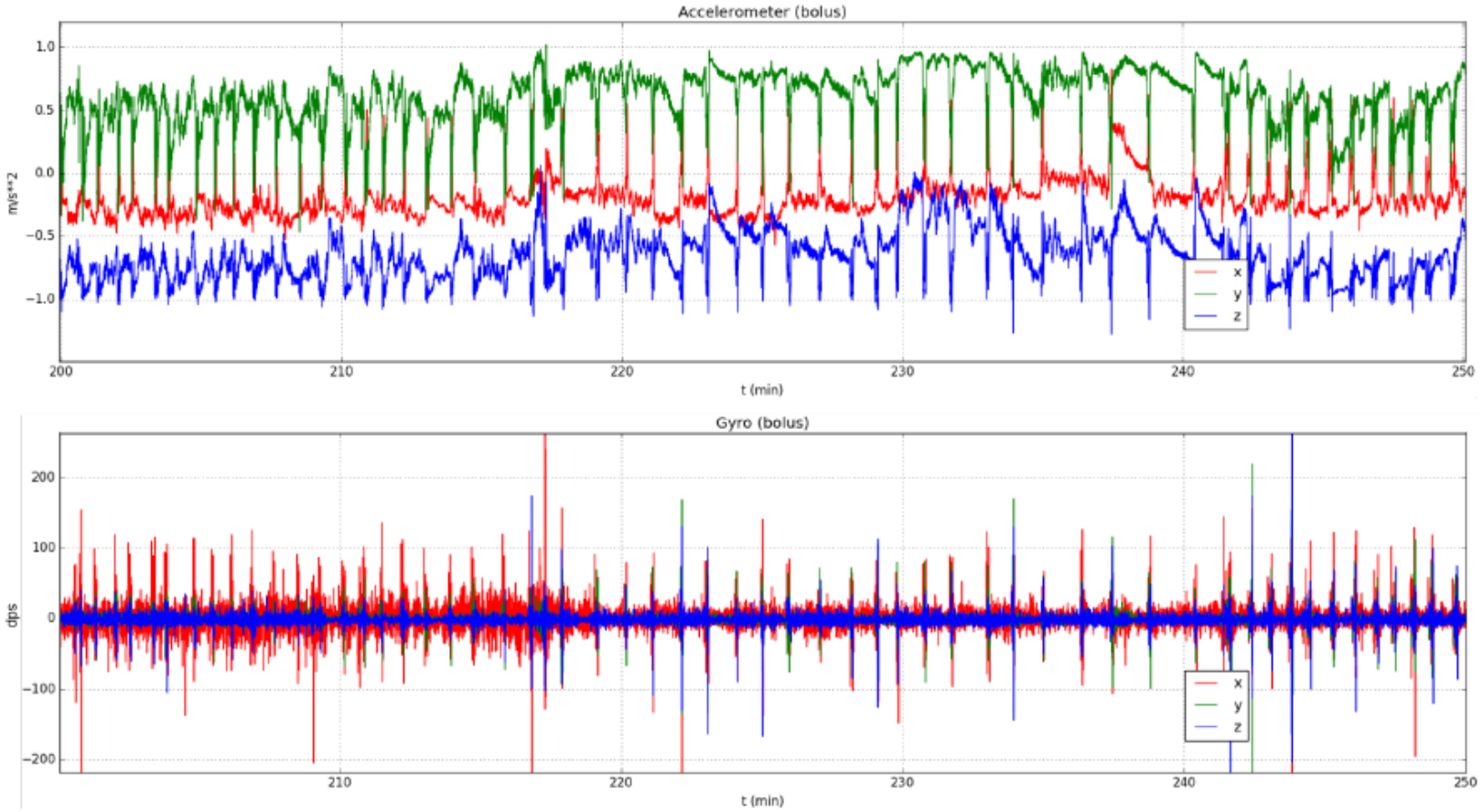


Bolus experiment with IMU (accelerometer + gyro)

- A Cypress (CY8C5888LTI-LP097, a 32 bits ARM) microcontroller was used to accelerate processing time.
- Sampling time was 6 values/s that reduces the battery life.
- Data was acquired in a SD card (6 Gbytes) in order to avoid the slow RF communication and to save battery power.
- Current option only temperature.



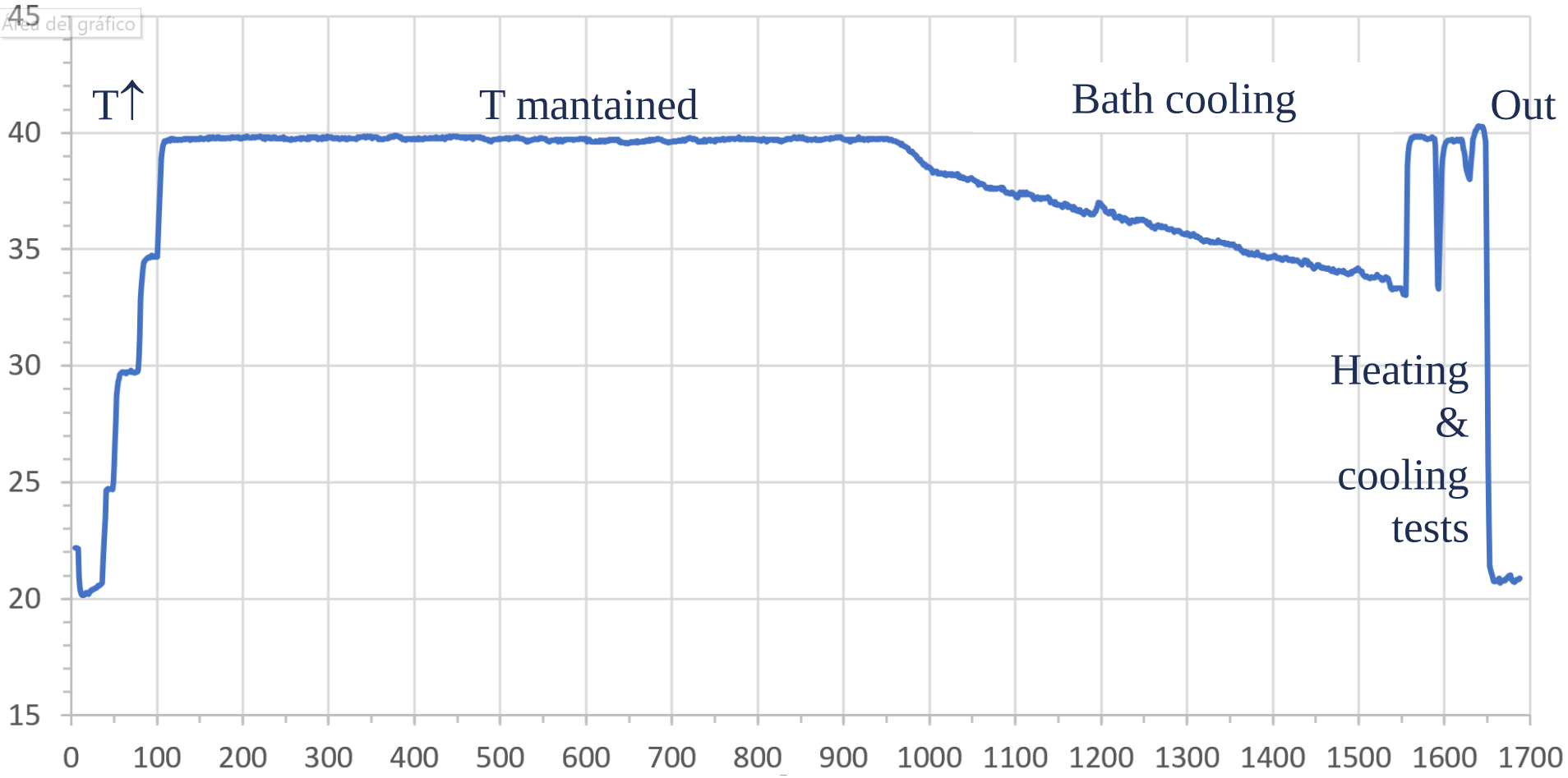
Experimental results: a 50 min window



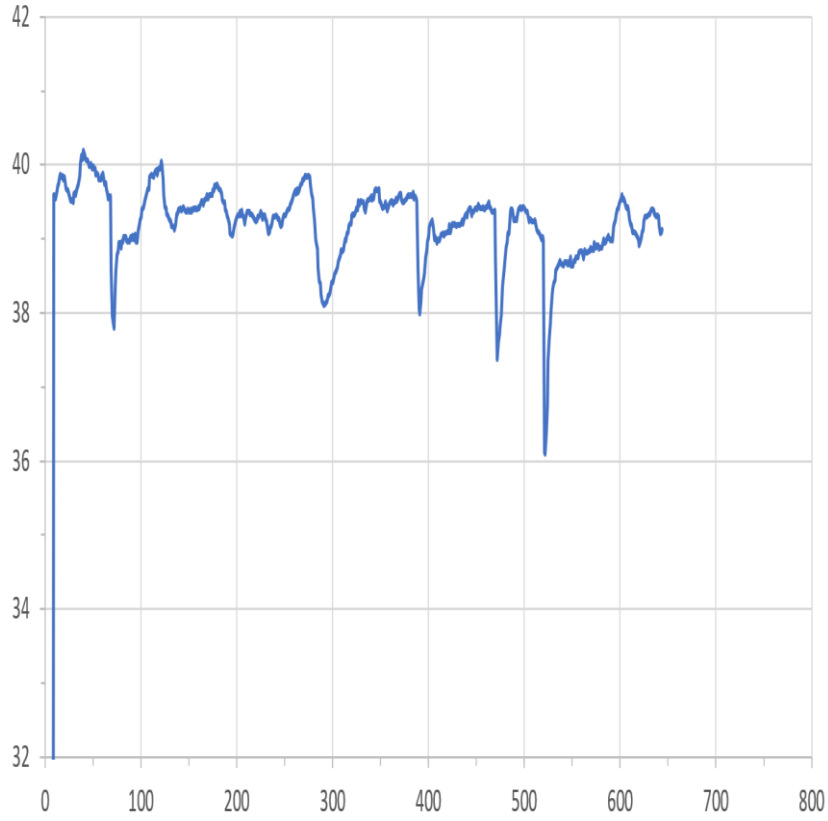
Final pre-commercial bolus (BT3)

- **Five bolus applied into lactating ewes:**
  - Weight: approximately 60 g.
  - Dimensions: 100 mm * 22 mm.
  - Material: Plastic PVC with glued sealing to the caps.
  - Programming setup: 103 ms. duration of data emission pulse.
  - Data captured: every 2.5 s.
  - Frequency: emission every 10 s.
  - Reading distance: 5-7 m.

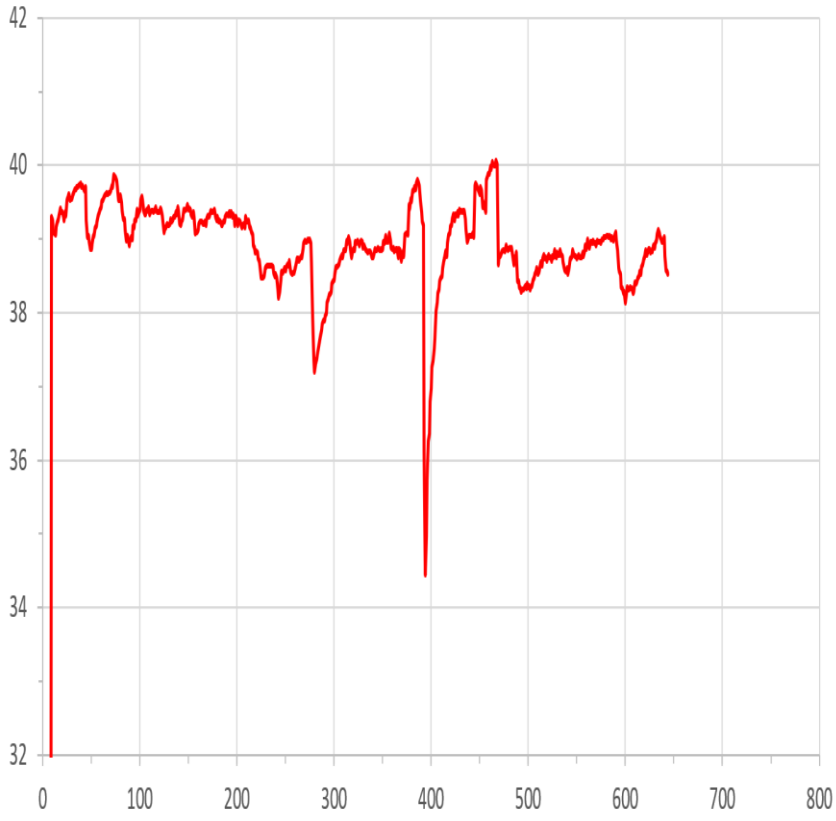
BT3 calibration test: Water bath



BT3 Experimental results in lactating ewes



Ewe1



Ewe2

Conclusions

- Suitable sized achieved for sheep heavier than 50 kg.
- BT1 bolus (glass packaged) short battery life as a result of heat during sealing process.
- BT2 bolus (plastic packaged) with or without IMU.
- BT3 bolus (PVC packaged) able to capture temperature every 2.5 s and transmit every 10 s.
  - Pre-serie of 150 (50 already produced).
  - Available for SWIG members.

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Thank you!!!

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